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RECOVERY OF THE PARASITE *TRIARTHRIA SPINIPENNIS* (MEIGEN) (DIPTERA: TACHINIDAE) FROM AN INLAND CALIFORNIA POPULATION OF THE INTRODUCED EUROPEAN EARWIG*

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Abstract.—A tachinid parasite, *Triarthria spinipennis* (Meigen), introduced over 50 years ago to control populations of the introduced European earwig in coastal California, is reported for the first time in California's Central Valley. Both the parasite and its host prefer cooler, more humid environments near water. Parasites were found during two consecutive years and abundance patterns within each year indicate they are multivoltine. The parasite has successfully accompanied its host's inland invasion from the coastal region of California.

Key Words.—Insecta, Dermaptera, Diptera, *Forficula auricularia,* parasitism, Tachinidae, *Triarthria spinipennis*

Since its arrival in the western United States shortly after the turn of the century, the European earwig, *Forficula auricularia* L., has extended its range throughout much of California (Essig 1931, Langston & Powell 1975). European earwigs are nocturnally and arboreally active foragers, giving them potential as biological control agents of orchard pests (Carroll & Hoyt 1984, Mueller et al. 1988). They are most noticeable in suburban environments where they commonly take diurnal refuge in the cracks and crevices of man-made structures. Early reports about the earwig suggested that its invasion might have a negative impact in California because of its feeding on economically important plant species (Essig 1918, 1925).

In an effort to thwart the invasion of the earwig, two endoparasitic tachinids, *Triarthria spinipennis* (Meigen) and *Ocytata pallipes* (Fallén), also referred to as *T. setipennis* (Fallén), were introduced into Oregon during 1924 (Mote 1931). *Triarthria spinipennis* was later released in the Bay Area of California (O'hara, in press). By 1967 it had been recovered in Alameda, Contra Costa, Del Norte, Humboldt, Marin, San Benito, San Francisco, San Mateo and Sonoma Counties (Arnaud 1967, Schoeppner & Hagen 1963). Here we report the first record of the parasite in the Central Valley of California, as well as information on the abundance and distribution of the parasite and its host.

MATERIALS AND METHODS

Data were recorded from sampling units made from wooden trap-nests (Krombein 1967) during a study at the Cosumnes River Preserve (CRP), located 32 km S of Sacramento, Sacramento County, California. A sampling unit (SU) consisted

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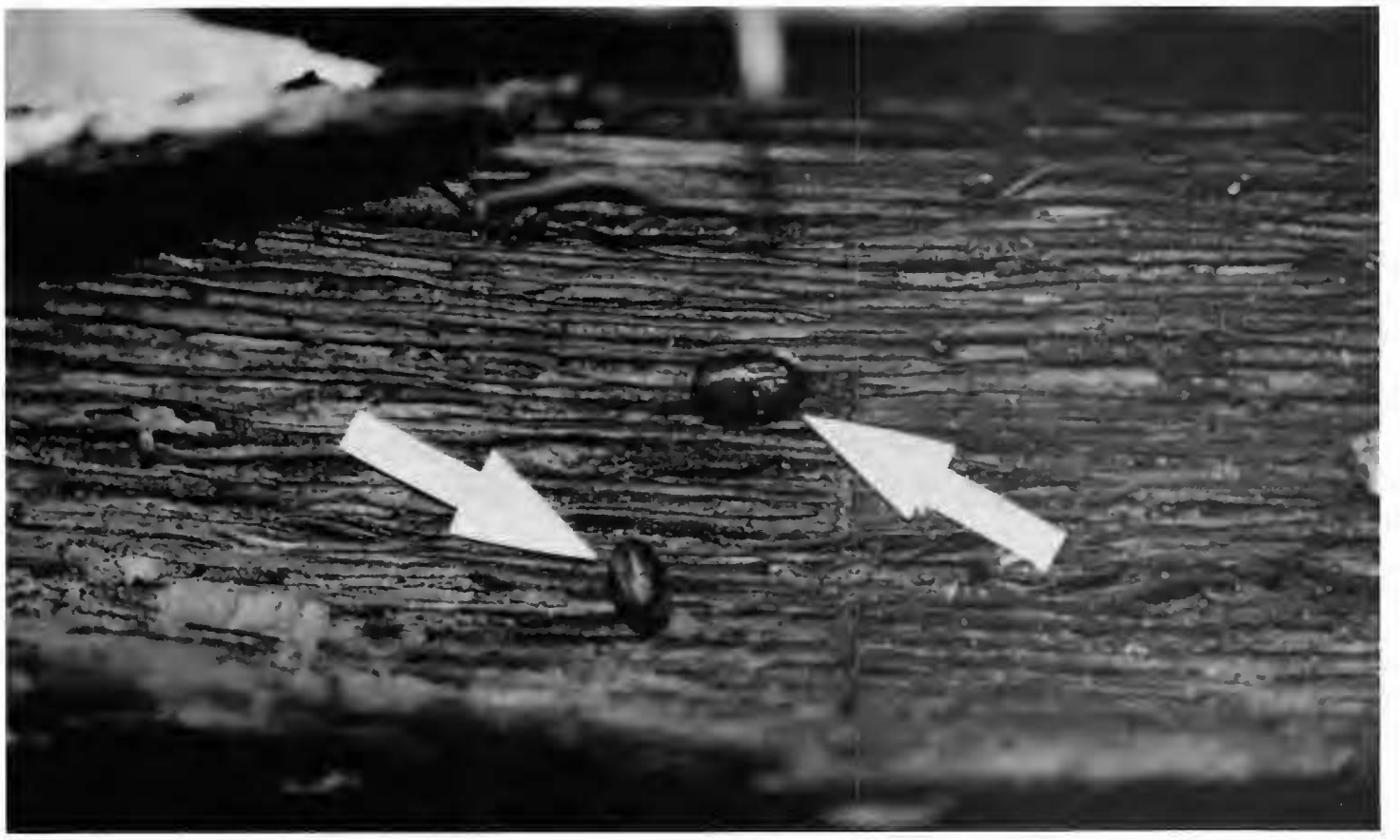

Figure 1. Tachinid puparia attached to the inner surface of tree bark where adult earwigs had aggregated (puparia are between .25 and .50 cm in length).

of 12 trap-nests, each with dimensions of 12.0 × 2.5 × 2.0 cm and with a single hole drilled to a 10 cm depth down its length. Four trap-nests for each of 3 hole diameters (.50, .65 and .80 cm) were systematically arranged within a 5.0 × 12.0 × 12.0 cm unit and hung with wire from nails at 1.5 m heights on valley oak trees (*Quercus lobata* Nee). Sampling units were spread approximately equidistantly along a belt transect in each of three oak habitats: marsh, riparian and grassland. During both years, each transect was of approximately equal length and ran E–W, paralleling the Cosumnes River which bisects CRP along its southern edge. During 1989 (5 May–6 Oct), 10 SUs were monitored per habitat on a biweekly basis. During 1990 (4 May–5 Oct) 15 SUs were monitored per habitat and sampled once a week to increase resolution of parasite/host abundance patterns. Field replacements were made on the same day of the week during both years so that sampling intervals would coincide.

After being removed from the field and replaced with a new SU, trap-nests were dissected in the laboratory and the number of adult earwigs and tachinid fly puparia counted. We were able to monitor puparia in trap-nests because earwigs remain active until shortly before the endoparasitic larvae emerge for pupation (Mote et al. 1931). Puparia are commonly found where adult earwigs normally aggregate during the day, such as under the bark of dead tree limbs (Fig. 1).

Results and Discussion

Numbers of earwigs were not evenly distributed among habitats during 1989 ($\chi^2 = 1007.90$; df = 2; $P = .0001$) or 1990 ($\chi^2 = 7004.85$; df = 2; $P = .0001$) with most appearing in the marsh and/or riparian habitats (Table 1). Parasite numbers were also significantly different among habitats during both 1989 ($\chi^2 = 15.00$; df = 2; $P = .0006$) and 1990 ($\chi^2 = 47.14$; df = 2; $P = .0001$). During 1990, however,

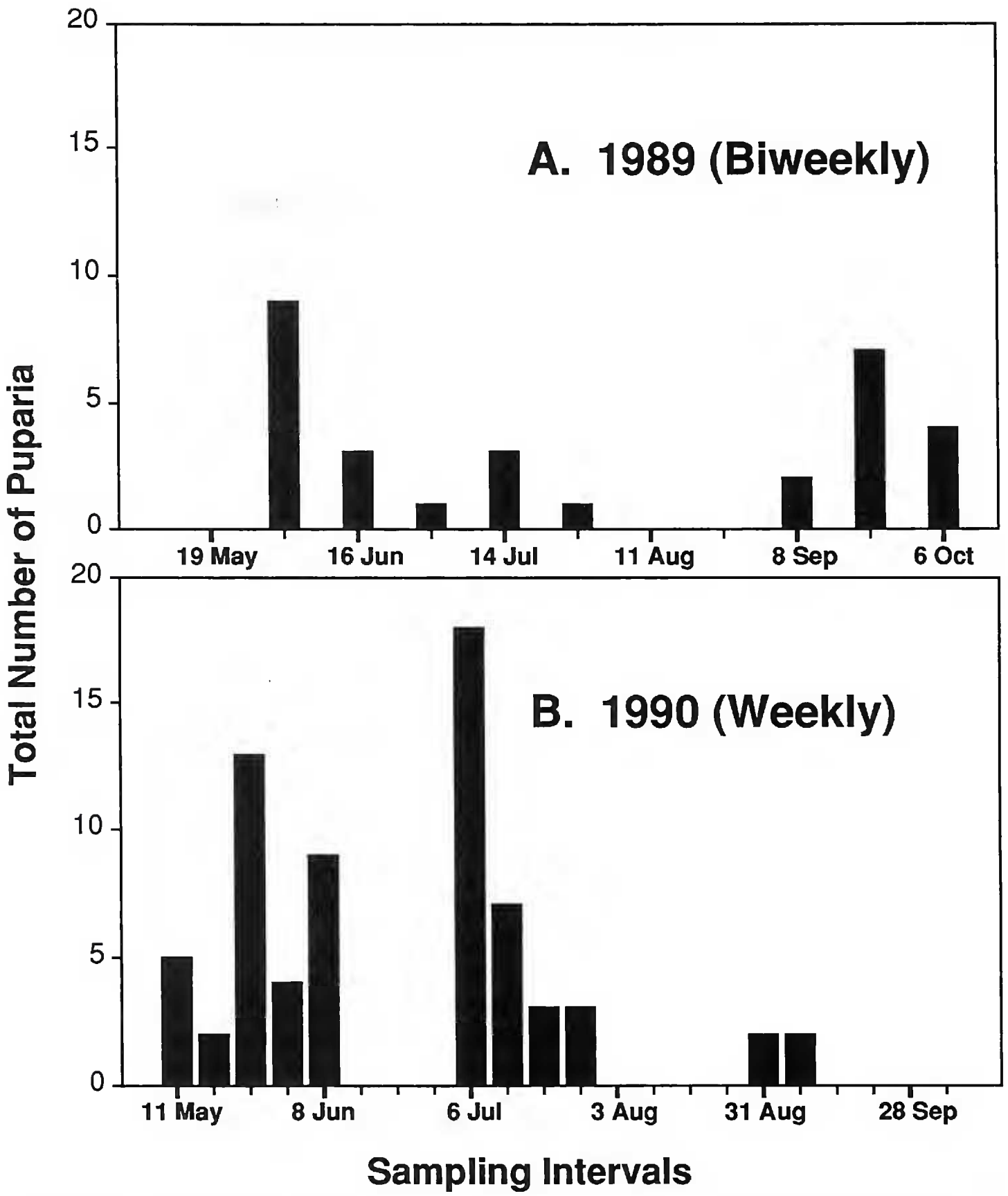

Figure 2. Abundance of tachinid puparia found at biweekly intervals during 1989 (a) and at weekly intervals during 1990 (b).

the number of puparia in habitats differed significantly from those levels expected based upon host numbers per habitat ($\chi^2 = 11.47$; df = 2; $P = .0032$), with all but one puparium occurring in the marsh and riparian habitats (Table 1). No puparia were recovered from the grassland during 1989, suggesting that the parasite, like its host, may avoid the exposed and drier conditions of this habitat type.

Overall numbers of puparia relative to adult earwigs were low during both 1989 ($n = 30$) and 1990 ($n = 68$) with parasitization levels $\leq 1\%$. However, these were

Table 1. Total numbers of earwigs and tachinid puparia (parentheses) found in each of three habitats.

Year	Marsh	River	Grass	Σ
1989	1327 (15)	1246 (15)	123 (0)	2696 (30)
1990	7784 (47)	1929 (20)	1280 (1)	10,993 (68)

undoubtedly low estimates of parasitization in the population because the parasites potentially contained within the earwigs counted from SUs had not necessarily completed their development. The exact contribution to earwig mortality therefore remains unknown at CRP, although 18% parasitization was recorded for a population in Danville, California (Schoeppner & Hagen 1963).

Both 1989 and 1990 data show temporal abundance patterns that are consistent with multivoltine parasite populations (Fig. 2). During 1989, there were two periods when tachinid puparia were continuously observed: 2 Jun–28 Jul and 8 Sep–6 Oct, with an intervening period of four weeks (two sampling periods) when no parasites were detected. In 1990 puparia were observed during three continuous periods: 11 May–8 Jun, 6 Jul–27 Jul and 31 Aug–7 Sep with intervening periods of three and four weeks, respectively, when no puparia were observed in trap-nests. Variation in host numbers between sampling periods may partially explain the uneven distribution of tachinid puparia during both years. However, the long periods (18–20 weeks) over which the parasites were noted during each year suggest that multiple generations of parasites must have developed since the developmental time of larvae ranges from 21–90 days (Mote et al. 1931), less than the period over which puparia were observed in either year.

Our data indicate a well-established population of the introduced tachinid, *T. spinipennis* in the Central Valley of California. The occurrence of puparia in sampling units during two consecutive years demonstrates that the parasite survived at least one overwintering period. The parasite appears to be able to follow its host (though less commonly) into more exposed and drier habitats such as the oak grassland in our study. The extended period over which puparia were observed during each year suggests the parasite is producing more than one generation per year as previously described for this species (Mote et al. 1931).

The presence of *T. spinipennis* in the Central Valley of California is an important finding because it demonstrates that the parasite can survive in both the coastal and Central Valley regions of California, two climatically distinct areas of the state. The majority of earwigs and tachinid puparia were found near cooler and more humid riparian habitats which is consistent with findings of other studies (Chant & McLeod 1952, Crumb et al. 1941). The riparian habitats in our study surround the Cosumnes River which eventually flows to the San Francisco Bay, where the European earwig was first noted in California (Essig 1923). It is, therefore, likely that the earwig and its parasite have used this river and other waterways as inland invasion corridors throughout the state.

Material Examined.—USA. CALIFORNIA. *SACRAMENTO Co.:* Cosumnes River Preserve, 6 Jul 1990, 2 males & 4 females; 13 Jul 1990, 1 male & 1 female. Specimens deposited in the California Academy of Sciences.

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